United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

Apr. 1, 1940

Foreign Plant Quarantines In-service Training Series. No. 7
(No. 1 is an introductory and explanatory number.)
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Name of disease: Flag smut of wheat.

Name of pathogen: Urocystis tritici Koern.
Syn. (For a time it was called U. occulta)

Hosts: Triticum spp.

Part attacked: Coleoptile, leaves, sheaths, stems.

Place of origin:

Country of first report: Australia, 1868. (7)

First report from U. S.: Collected May 11, 1918, in St. Louis County, Mo., but not reported until after it was found May 5, 1919, in Madison County, Ill. (5, 17)

Present distribution: Australia, Bulgaria, China, Cyprus, Egypt, India, Italy, Japan, South Africa, Spain, Tasmania, Transcaucasia, Tunis, United States (the Plant Disease Survey received no reports of the occurrence of flag smut in 1937 or 1938 but had reports of slight local infections in Kansas as late as 1936, in Illinois in 1934 and in Missouri in 1933.) (2, 7, 10, 13, 14, 18) Washington, 1940

Factors affecting severity: Susceptibility of host, and moisture and temperature factors related to the germination period of the host are important. Grain sowed before the fall rains is more heavily infected than if sown late in the season. If the soil is rather dry when the wheat germinates and for a few days thereafter, infection may be relatively light and if the soil is wet there is little infection. Infection is reduced if the soil temperature gets too high or too low, the optimum varying according to different workers but apparently not far from 20° C. The number of spores overwintering and present in the soil in condition to germinate readily is important.

It is quite possible that, as in other fungi, the particular physiologic form or forms present in abundance in any given year and locality are important factors in determining the losses incurred. (4, 7, 8, 9, 10, 13, 15, 18, 19)

Methods of spread: Local spread is largely by air currents, in manure, in straw, in surface water, and on farm implements. Both local and long distance spread is accomplished by use

of seed wheat with adhering spores. Infected straw might carry the disease long distances if baled and shipped for use as bedding for animals and afterward sold for fertilizer or if carried down stream in flood waters. (2, 4, 7, 12, 15, 16)

Losses incurred: Losses are extremely variable on the same host varieties, in the same localities during different seasons.

Comparative losses: It has been estimated that losses from flag smut average 3 to 4% of the crop in Australia; in China, up to 90% or more of the plants may be infected; in lower Egypt, losses are appreciable but the disease is less prevalent in upper Egypt; in India the losses are slight; in Italy losses were usually slight but in 1931-2 reached approximately 20% in some places; in South Africa yields were reduced as much as 20% in some fields; in Transcaucasia losses were slight when the disease was first noted but increased rapidly in succeeding years; in the United States losses are negligible in general owing to the growing of resistant varieties but losses in portions of fields have been as high as 30%. (2, 6, 7, 13, 14, 16, 18, 19)

Control methods: Quarantines are used to prevent spread to new areas. Where the disease is established the most effective control is the use of resistant varieties. Seed disinfection, destruction of infected straw and manure, crop rotation and late fall planting are recommended as supplementary control measures. While some of the spores may remain viable in the soil for several years, most of them lose their vitality within a year or two apparently so a relatively short rotation should prevent serious losses. (2, 3, 7, 12, 17, 18)

Quarantine action: The quarantine on account of flag smut and take-all diseases, No. 39, was promulgated July 2, 1919, effective Aug. 15, 1919. Australia, India, and Japan were the only countries in which flag smut was known to occur. The flag smut disease quarantine, No. 59, was promulgated Dec. 31, 1925, effective Feb. 1, 1926. This quarantine superseded quarantine No. 39, omits the take-all diseases, and extends the list of countries covered to include India, Japan, China, Australia, Union of South Africa, Italy and Spain. Wheat (Triticum spp.) and wheat products, except such as have been so milled or so processed as to have destroyed all flag smut spores, are covered.

On July 15, 1919, a public hearing was held to consider the desirability of promulgating a domestic quarantine to prevent spread of flag smut from the known area of infection in Illinois. Imposition of a state quarantine by Illinois

made it appear unnecessary to establish a federal domestic quarantine on account of flag smut. Hope was expressed that the disease would be eradicated.

While flag smut has not been eradicated in this country, it is extremely difficult to find specimens of it in the field. New and better varieties of wheat which are resistant to flag smut are being grown in the states where the disease gained a foothold.

Important wheat varieties grown on the Pacific Coast are not resistant, and the wheat growing areas there are said to have conditions approximating those of regions in Australia and elsewhere in which flag smut damage is greatest. Until satisfactory resistant varieties for this Pacific Coast area have been provided, it is deemed necessary to protect it by maintaining quarantine No. 59. It is expected that such resistant varieties will be available soon. At that time consideration may be given to the question of reciding the flag smut quarantine.

Before reciding the quarantine, however, it will be desirable to determine the status of physiologic strains of the smut. Since known strains vary markedly in virulence and some of them may be destructive to the wheats found to be resistant to the form or forms introduced into this country, the need for the quarantine may be as great as it ever was. (17, 19)

Description: The symptoms of flag smut infection are characteristic but their time of appearance and distribution on infected plants is variable. Symptoms sometimes show as early as on the fourth leaf to form; at other times no symptoms show until the plant is nearly grown and then on the upper parts of the plant only. The earliest symptoms are more or less elongated stripes on the young leaves or flags. These stripes are white at their base, becoming whitish gray further up and lead-gray toward the tip of the leaf. As the spore masses mature the stripes become grayish-black, or in some cases dark brown. Finally the stripes become very dark and rupture exposing the masses of black sooty spores. Until the spores reach full size infected plants may appear to be as vigorous as healthy ones, but later the leaves and upper part of the culms are likely to become twisted and curled. Infected plants may have only part of the culms infected. If heads are produced on infected culms, they may be small and obviously sterile or they may appear normal but contain few or no grains. Where heads are produced there may be no striping except on the glumes at the base of the head and on the culm just below the head.

It seems possible that the number of culms showing the disease in a single stool depends on the number and vigor of the hyphae present in the plant, these in turn being

dependent on the number of spores producing infections in that plant, and on the susceptibility of the plant.

Noble reports the production of spores on the fifth leaf of a plant only 29 days after inoculation, but the incubation period is usually longer, approximately six weeks in Noble's experiments.

When the stripes on the leaves rupture exposing the masses of spores, these are readily scattered by any movement of the plant, fall to the ground, are blown about by the wind or adhere to anything that comes in contact with them. During threshing the grain may become contaminated with numerous adhering spores. Spores may occur singly or two to several in a spore ball and are surrounded by a single layer of sterile pale brown cells.

Spore sizes as given by Butler are 9-16 mu in diameter; by Noble, 12-16 x 9-12 mu; and by Verwoerd, 12.6-18 x 8-9.6 mu. The size of the sterile peripheral cells is given by Noble as 7-10 x 5-9 mu.

The spores seem to need a rest before germinating, but the length of the rest period depends on the conditions under which it occurs and the conditions existing or provided when germinability is tested. Spores may germinate within a few weeks after they reach maturity or they may remain viable in the soil for years before germinating and causing infection. If conditions are otherwise favorable, the presence of seedlings of wheat, or of any one of several other plants that are not hosts of the fungus, may stimulate the germination of many of the spores present. Thus the growing of non-susceptible plants may greatly reduce the number of viable spores present in the soil. It was found that resistant wheat varieties were infected as readily as susceptible varieties but the fungus was unable to make rapid growth after it gained entrance. The fungus is able to produce spores on some resistant varieties. In order to eradicate the fungus, varieties on which spores are not produced should be grown.

Infection normally takes place in the coleoptile only. The coleoptile may be infected at any time after it breaks through the seed coat until it is broken to permit the first true leaf to emerge. While the time required for the coleoptile to make this development varies considerably, it is normally only a few days. It appears that the smut spores do not germinate readily unless previous temperature and moisture conditions have been such as to prepare them for germination. Hence the coleoptile may emerge and break under conditions that appear to be favorable for infection but without much infection taking place because the spores were not in condition to germinate at that particular time. Age of spores as well as temperatures, moistures, and length of duration of the temperature and moisture conditions, and

their variations, and perhaps soil acidity, and other conditions are involved in determining whether or not spores will germinate at a given time under the conditions then prevailing. When all factors are favorable for the fungus, heavy losses result.

The role of physiologic races in the flag smut problem has received little or no attention from most investigators. Verwoerd states that he found no physiologic strains notwithstanding the fact that in his experiments the South African form appeared to be more virulent than the American form. Yu, Hwang, and Tsiang demonstrated 5 physiologic strains in Chinese material tested over a four-year period. A study of this phase of the problem is important to wheat breeders and to quarantine officials particularly. (1, 2, 4, 6, 7, 8, 9, 10, 11, 12, 15, 18, 19)

Bibliography:

(1) Angell, H. R., Hely, F. W., and Allan, F. E.
1937 The effect of Urocystis tritici Koern. on the extent of development of the roots and aerial parts of the wheat plant. I, II, J. Coun. Sci. & Indus. Res. 10: 136-142, May 1937 and 11: 256-257, Aug. 1938.

The reduction in the root system of infected plants is influenced by environmental conditions, being more pronounced in winter grown plants than in spring grown plants.

The root system of Federation, a susceptible variety, was less affected than that of Ford, moderately resistant, and Nabawa, resistant. In Federation the weight of tops was reduced, in Nabawa it was increased, while in Ford there was a reduction in one of two experiments.

(2) Butler, E. J.
1918 Fungi and disease in plants. 547 pp. 1918 (Flag smut on pp. 171-173.)

Flag smut (Urocystis tritici Koern.) is confined to the Punjab in India and does relatively little damage there. The spores are formed in tiny balls consisting of 1 to 4 fertile bright brown spores, surrounding which is a layer of light-colored sterile cells. Spores spherical or oval, 9 to 16 mu in diameter, spore balls up to 40 mu in diameter. Sterile cells are smaller, more elliptical.

Old smutted straw will cause infection at sowing time. Manure from horses fed infected straw carries infection also. Flag smut persists in the soil.

Crop rotation important.

(3) Faris, J. A., Tapke, V. F., and Rodenhiser, H. A.
1933 Wheat smuts and their control. U. S. Dept. Agr. Farmers' Bul. No. 1711.

Quarantine and sanitation are recommended to prevent introduction of flag smut into new areas. Treatment of seed as for stinking smuts or bunts will kill adhering spores but will not affect spores in the soil. The use of resistant varieties is recommended in infected areas.

(4) Griffiths, Marion A.
1924 Experiments with flag smut of wheat and the causal fungus, Urocystis tritici Kcke. Journ. Agr. Res. 27: 425-449. Feb. 16, 1924.

Infestation of soil rather than of seed was the most important factor in the annual occurrence of the disease in Australia. Flag smut reported to occur in the United States, Australia, Japan, China, India, South Africa, Italy, and Spain.

Symptoms are detailed.

Urocystis tritici is not known to infect plants of any genus other than Triticum.

Spores solitary or two to several, invested by a layer of small sterile cells. Each spore of a spore ball may germinate but usually only one or two do so. On germination the spore sends out a promycelium with a whorl of one to several sporidia at the apex. The sporidia do not separate from the promycelium but elongate to form "infection threads." Sizes vary with conditions of germination. Spores collected in Australia in 1919 gave 100% infection when used in 1921-22. Spores buried two and six inches in soil out of doors remained viable until early spring. Studies are detailed on relation of date of sowing, temperature, and stage of growth to infection. The highest percentage of infection occurred at 21.5° to 23.5° C. The most favorable stage of growth for infection was in the seedling stage before the coleoptile was broken and before the seedling emerged from the soil.

(5) 1919 Humphrey, H. B., and Johnson, A. G.

Take-all and flag smut, two wheat diseases new to the United States. U. S. Dept. Agr. Farmers' Bul. 1063. Aug. 1919.

Flag smut was found May 5, 1919, in Madison Co., Illinois, when pathologists assembled to get acquainted with the take-all disease. Of 121 fields covered in the first preliminary survey 23 had flag smut, some spots showing as high as 2% infection. Within a few days the disease had been found in three Indiana counties, La Porte, Porter, and Tippecanoe. Later it was found in Sangamon and Mason counties, Illinois, also. --Source of disease unknown.

Symptoms and control discussed.

(6) 1932 Jarrett, Phyllis H.

Investigations of flag smut of wheat. Journ. Australia Council Sci. & Indus. Res. 3: 165-169. 1932.

Flag smut has never assumed epidemic proportions but takes a steady annual toll.

Use of resistant varieties is the best control method.

Entrance of the fungus into the host only occurs through the young entire coleoptile, i.e., before this white sheath has been broken by the first true leaf. Germ tubes enter resistant and susceptible varieties alike. Unable to keep up with host growth in resistant varieties, but may show in small smutted shoots from the lower nodes of the main tiller. In susceptible varieties the growth rate of hyphae corresponds to that of the meristematic tissues of the host but no outward symptoms show until the fourth or fifth leaf stage in artificially grown plants and much later usually in

the field.

Different varieties react differently to flag smut under similar conditions and individual plants of a variety react differently. Plants of Aussie, Canberra or Federation may die at the fourth to the sixth leaf stage or may live to produce one or two heads with few or no grains. Plants of Bunyip, Geeralying or Nabawa may show infection in one or two tillers only or appear quite healthy, microscopic examination being necessary to show the presence of the hyphae in the base of the plant. Effect on yeild is the best way to measure effects of flag smut. Experiments along this line were carried out but results are not given.

A method for determining the degree of resistance of varieties for comparative purposes is presented and resistance of varieties tested is tabulated.

(7) McAlpine, D.
1910 The smuts of Australia. 285 pp. 1910 Urocystis tritici Koern. pp. 88-102.

U. tritici and U. occulta compared, latter does not cause distortion or twisting of the flag or blade of the rye leaf and the streaks are principally noticeable on the stems instead of on the leaves. Plants with flag smut of wheat do not usually form heads while plants with stem smut of rye usually form skeleton ears which are likely to droop.

A report of "Black Rust" in South Australia in 1868 is believed to be the earliest record of U. tritici in Australia, although it was an old established disease at that time apparently.

Early and self sown crops are said to suffer most.

Dry sowing tends to increase the disease.

Dry spores germinated in water in 24 hrs. Promycelium 1-6 usually 5 or 6-celled, up to 100 mu long by 3-5 mu, with 2-6 usually 3-4 conidia at the apex.

Mycelium was obtained in young leaf tissue 10 days after wheat was sown. Infection was obtained by using straw, chaff, horse manure.

Infection does not occur after the plant is above ground.

(8) Miller, W. B. and Millikan, C. R.
1934 Investigations on flag smut of wheat caused by Urocystis tritici Koern. Journ. Dept. Agric. Victoria, 32: 365-380, July 1934. And under same title and authors, II 418-432. Aug. 1934.

In susceptible varieties there are usually more plants totally infected than partially infected while the reverse is true of resistant varieties.

Germination of spores and infection of host are favored by soil temperatures above 50° F. and only moderate moisture,

or by conditions prolonging the period of susceptibility of the host.

Severe infection occurred in soils ranging in PH from 5.5 to 8.7.

The ratio of reduction in yield to percentage of smut was greatest in resistant varieties, apparently due to the fact that infections present on resistant varieties did not always show.

Deep sowing tended to increase infection.

p. 366 - "Unlike rust, this disease seldom assumes epidemic proportions, but takes a steady annual toll of the wheat crop."

p. 373 - "The amount of inoculum applied determined to a large degree the percentage of smut which developed."

p. 377 - "It is found that in general the number of "partial" infections greatly exceeds "whole" infections in resistant varieties, but the reverse is not always the case in susceptible varieties....."

p. 378 - Counts made ..."indicate that there is a marked tendency for the symptoms to appear much later in resistant varieties, in contrast with those more susceptible to the disease."

p. 380 - "If the soil is very wet during the susceptible period, infection is low, even though the temperature is favorable.

The minimum temperature for germination depends upon the moisture present."

(9) Noble, R. J.
1923 Studies on Urocystis tritici Koern., the organism causing flag smut of wheat. Phytopath. 13: 127-139. March, 1923.

A study of the conditions under which U. tritici spores germinate, in the laboratory primarily. p. 137. - "Soil moisture, soil temperature, soil aeration, and the presence of a stimulatory substance at any given time may not be necessarily conducive to infection. It would appear that these factors must operate in the proper order and must be correlated chronologically. Sometimes the factors may operate together in nature in such a manner as to cause the development of flag smut epidemics."

Tissues from any part of seedlings of cereals and other grasses and uninjured wheat seedlings stimulated spore germination. The minimum temperature for spore germination was about 5° C., maximum about 32° C., optimum apparently between 18 to 24° C.

The optimum temperature for germination depends on previous moisture conditions of the spores. The promycelium produced by a germinating spore usually becomes 20 to 30 x

5 mu before forming 1 to 6, usually 2 to 4 sporidia. Sporidia are more or less cylindrical and when fully formed are about 30 x 5 mu. Sporidia sometimes fuse.

(10) 1924 Noble, R. J.

Studies on the parasitism of Urocystis tritici Koern., the organism causing flag smut of wheat. Journ. Agr. Res. 27: 451-489. Feb. 16, 1924.

Occurrence reported in Australia (1868), Japan (1895), India (1906), Southern Europe, Italy (1922), Transvaal (1920), China and United States. Symptoms given. Pathogen called Urocystis occulta (Wallr.) Rab. by Wolff in 1873 but Koernicke described it as a separate species in 1877.

Spores may occur singly or in spore balls of two or three spores or sometimes more. Spore balls are dark brown, usually globose but variable, usually 18-52 x 18-45 mu. Individual spores spherical or oval, 12-16 x 9-12 mu. The spores whether single or in spore balls are usually completely invested with a layer of sterile peripheral cells, pale brown, globose or ellipsoid, 7-10 x 5-9 mu. On germination a promycelium and sporidia are produced.

Spore germination was studied, germination being obtained by a period of soaking following a rest period or maturation period, and stimulating by use of seedlings or wheat seedling sap. Certain chemicals stimulated germination also. Relative humidity of 50-75% was found most favorable for retention of viability, spores kept at such humidities and temperatures of 5° to 26.5° C. germinating readily in distilled water.

Infection did not depend on amount of inoculum but on suitable conditions for infection, moisture, soil temperature, condition of host. Optimum soil temperatures for infection ranged from 14° to 21° C.

The mycelium is intercellular.

Disease lesions may first appear at any stage in the growth of the host up to heading, the earliest noted being on the fifth leaf 29 days after inoculation, although the fourth leaf is sometimes first affected.

Losses from the disease are about 3% in Australia although losses in individual fields may be 70%.

Bibliography of 58 titles.

(11) 1934 Noble, R. J.

Note on the longevity of spores of the fungus Urocystis tritici Koern. Journ. & Proc. Roy. Soc. New South Wales 67: 403-410. 1934.

Spores collected in New South Wales in 1923 and kept relatively dry in the laboratory still germinated vigorously in 1933. None of the spores kept at relative humidities of 72.5 and 89% were found to germinate at any time during the

ten-year period (Perhaps owing to contamination, mainly Penicillium.)

All lots kept at relative humidities of 33.5 or less gave more than 50% germination at the end of ten years.

(12) Reed, G. M. and Dungan, Geo. H.
1920 Flag smut and take-all. Ill. Agr. Exp. Sta. Circ. No. 242. July, 1920.

Report appearance of the diseases in Illinois. Discuss symptoms, distribution methods, control and susceptibility of wheat varieties.

(13) Rivera, V. and Corneli, E.
1933 Progressivo estendersi di epidemie da 'Urocystis' su Frumento, Riv. Pat. Veg. 23: 171-176, 1933.
(Abstract in R.A.M. 12: 681-2, 1933.)

Flag smut has been present in Italy for years but since 1928 has been getting increasingly severe, perhaps as much as a 20% loss in individual fields. The disease was equally severe on wheat sown early in dry weather and sown late after very wet weather. Spores left in the soil make the disease worse on successive crops.

(14) Szembel, S. I.
1934 Threat to wheat in Transcaucasia. Crop Protection 1934, Moscow, pp. 22-23. Translated title and citation in Rev. Appl. Mycol. 14: 23. Jan. 1935.

Urocystis tritici was recorded in 1930 as being present in insignificant amount in the southwestern littoral of the Caspian Sea. It spread rapidly until in 1934 up to 20% of the wheat fields in the Republic were infected, affected plants remaining unproductive. Steps are being taken to determine the extent of infection with a view to putting on a strict quarantine.

(15) Tisdale, W. H., Dungan, G. H., and Leighty, C. E.
1923 Flag smut of wheat, with special reference to varietal resistance. Ill. Agr. Exp. Sta. Bul. No. 242. April, 1923.

The infected area in Illinois is about 50 miles long and 5 to 15 miles wide, an adjacent infected area in Missouri including four fields only. Disease said to be spreading. Losses not severe as yet but parts of fields showed infections as high as 30%, indicating that the disease may become serious, as it has elsewhere.

A chief source of infection is spore balls adhering to the seed and contaminating threshers, wagons, bins, etc. Another is spores in the soil from straw or manure or carried by wind, streams, animals, or vehicles which have passed through infected areas.

Longevity of the spores is unknown, but some overwinter.

Wheat should not be planted in the fall following infected wheat. Spring wheat and late fall sown wheat are not so likely to be infected as that sown in early fall. Susceptibility of some varieties is indicated.

(16) 1923 Tisdale, W. H., Dungan, G. H., and Leighty, C. E.
Flag smut of wheat. U. S. Dept. Agr. Dept. Circ. 273, 6pp. June, 1923

Flag smut found in 5 more contiguous counties in Illinois since 1919, in 3 adjacent counties in Missouri near St. Louis, and in several counties in northwestern Missouri and northeastern Kansas - near Kansas City. Losses small, usually not over 1% of the plants infected except in small spots in fields. Symptoms, control, resistant varieties. The principal varieties grown in the flag smut area are susceptible.

(17) 1927 Tisdale, W. H., Leighty, C. E., and Koehler, Benjamin
Further studies on flag smut. U. S. Dept. Agr. Dept. Circ. 424, 11 pp., July, 1924.

Disease first discovered in this country by S. M. Zeller on May 11, 1918, in St. Louis Co., Mo.

Apparently not getting any worse in infected area. Perhaps the greatest danger from flag smut in the United States in the future lies in its possible spread to the Pacific Coast States, where the climatic conditions are similar to those in Australia, and where wheats susceptible to flag smut are grown.

Seed treatments and varietal resistance are reported.

(18) 1929 Verwoerd, Len.
The biology, parasitism, and control of Urocystis tritici Koern., the causal organism of flag smut of wheat (Triticum spp.) and recording the occurrence of Urocystis occulta (Wallr.) Rab., in South Africa as the cause of 'stem smut' in rye. (Translation.) So. African Dept. Agr., Sci. Bul. 76, 52 pp. 1929.

Flag smut occurs in the Western Province and Transvaal, up to 24.5% of the plants being infected by actual counts. Yields from diseased plants varied, the reduction being 90% or more in some varieties. The optimum temperature for spore germination is 22° to 24° C., the optimum temperature for infection is 22° C. Presoaking for three days and dessicating with sulphuric acid hastens germination. Spores remain viable 5 years, in soil they remain infective at least 4 years. The disease is more prevalent in soils with a high moisture content. No physiological strains were found but the South African form seems more virulent than the American form, producing 66.7 and 45% infection on Michikoff and Illini Chief varieties as compared to 32.6

and 21%.

Spores are 8-9.6 x 12.6-18 mu; spore balls 27-45 x 23.4-36 mu; promycelium 23.4-28.9 x 4.5 mu, sometimes 45 to 63 mu long; sporidia averaging about 25.2 x 4.5 mu when mature.

Thirty-seven percent of the spores tested after 5 years germinated.

Results show that the susceptible period is between the time at which the coleoptile penetrates the epidermis up to the time the coleoptile breaks, after which period no further infection occurs.

A high percentage of moisture interferes with spore germination and hence with infection. The disease is worse in fields sown before the first rains.

(19) 1936 Yu, T. F., Hwang, L., and Tsiang, C. T.

Varietal resistance and susceptibility of wheats to flag smut (Urocystis tritici Koern.) III. Physiologic specialization in Urocystis tritici Koern. Bull. Chin. Bot. Soc. 2: 111-113. 1936.

Urocystis tritici attacked at least 90% of the crops in Siao Hsien, Kiangsu and caused from a trace up to 94% infection in 37 localities in 8 provinces.

Four years inoculation tests with collections from different parts of the country on ten wheat strains enable the authors to differentiate 5 physiologic forms of U. tritici. Nanking wheat No. 716 was resistant to forms 1, 2, and 3; susceptible to 4 and 5. No. 799 was resistant to 1 and 2 but susceptible to 3. No. 793 was resistant to 1 but susceptible to 2 and 3. No. 795 was resistant to 4 but susceptible to 5. No. 796 was resistant to all five forms, and No. 800 and H. 1102 were susceptible to all five forms.

The percentage of smut obtained on the different wheats (which were uniform selections specially grown) varied somewhat from year to year and with the wheat strain used.

Detailed infection percentages are given for 10 wheats for each of 4 years using smut strains from 7 localities. These are said to be only a part of the numerous tests on which the conclusions are based.

Urocystis tritici

Plate 1

A.--Upper leaves of a wheat culm infected with Urocystis tritici, showing the long stripes, or sori.

B.--An enlarged portion of a wheat leaf infected with Urocystis tritici, showing the smut sori.

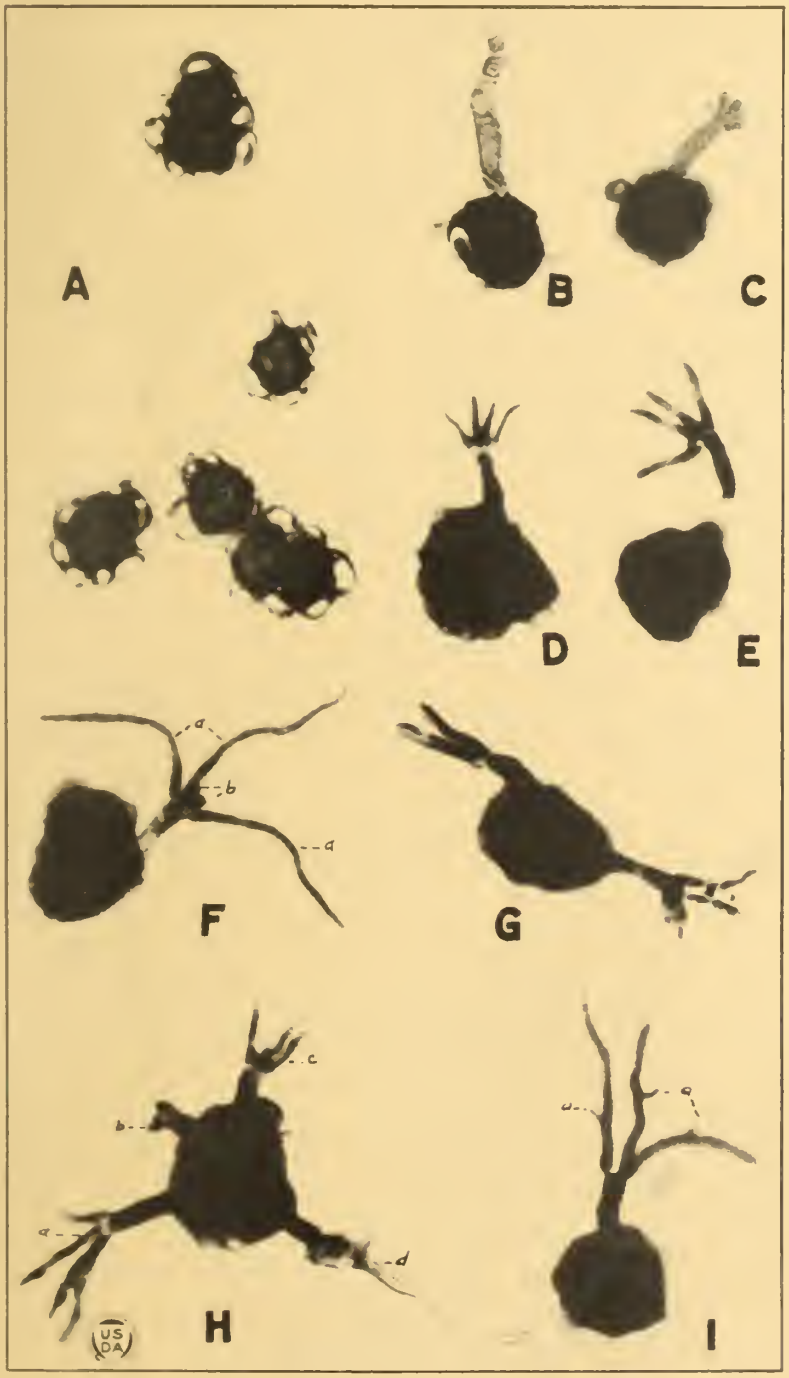
C.--Flag smut lesions on the lower glumes of an infected wheat head (a), and on the leaf sheath (b).

D.--Lesions of Urocystis tritici on the lower glumes (a), the rachis (b), and the upper part of the culm (c).

(From Jour. Agr. Res. 27: 425-450. Feb. 1924. Plate 1)

Urocystis tritici

Plate 2



Germination of spores of Urocystis tritici, photographed using 4 mm. objective and No. 10 ocular by Miss Ruth Colvin.

A.--Spore balls.
B.--Showing promycelium.
C.--Sporidia forming at apex of promycelium.
D, E, & G.--Germinating spores with sporidia.
F.--Sporidia elongating, forming so-called infection threads (a). Two sporidia (b) did not elongate.
H.--Spore ball with four spores in different stages of germination.
I.--Three sporidia, each with a secondary sporidium.

(From Jour. Agr. Res. 27: 425-450. Feb. 1924. Plate 2.)